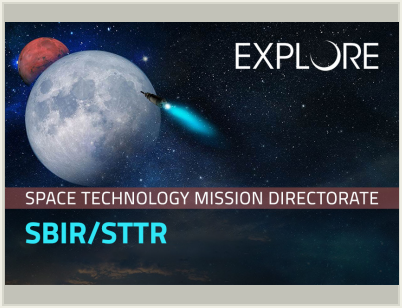
# High Fidelity Multi-Scale Regolith Simulation Tool for ISRU, Phase II

Completed Technology Project (2009 - 2011)

## Project Introduction

NASA has serious unmet needs for simulation tools capable of predicting the behavior of lunar regolith in proposed excavation, transport and handling systems. Existing discrete element method (DEM) or finite element (FE) models lack adequate fidelity for fine cohesive powders comprised of friable particles with irregular shapes and exhibiting substantial bulk dilation upon initial excavation. As such, they are inadequate for assessing the reliability of regolith excavation and handling systems, and even less so for evaluation of engineering trade-offs between total system mass, power and energy consumption. Also, current simulation tools do not include the effects of triboelectric and photo-ionization-induced charges on regolith particles. Building on the successful Phase-1development of a new charge-patch electrostatic model and a comprehensive cohesive particle interaction model for DEM, Grainflow Dynamics proposes to develop a high-fidelity predictive calculational tool, in the form of a DEM module with calibrated interparticle-interaction relationships, coupled with a FE module utilizing enhanced, calibrated, constitutive models which, together, are capable of mimicking both large deformations and the flow behavior of regolith simulants and lunar regolith under conditions anticipated in ISRU operations. This will not only provide unparalleled fidelity but also will leverage the computational efficiency of the continuum FE codes to drastically reduce the simulation time and resources necessary to perform engineering analyses on regolith systems. In addition, the modules will be parallelized to maximize their usefulness in multi-core and cluster computing environments. This work will lead to an improved engineering design tool that can be used by NASA engineers and contractors developing designs for ISRU equipment to evaluate both the reliability of various configurations as well as the trade-offs of system designs.

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## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Center / Facility:**

Glenn Research Center (GRC)

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

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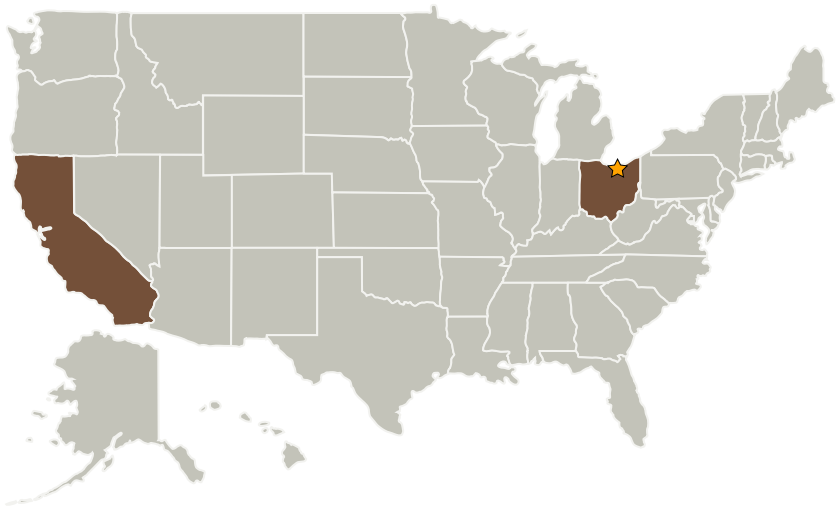
## Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| ★Glenn Research Center(GRC) | Lead Organization | NASA Center | Cleveland, Ohio |
| Grainflow Dynamics, Inc. | Supporting Organization | Industry | Livermore, California |

| Primary U.S. Work Locations | |
|---|---|
| California | Ohio |

## Project Transitions

**January 2009:** Project Start

**February 2011:** Closed out

## Project Management

**Program Director:**

Jason L Kessler

**Program Manager:**

Carlos Torrez

## Technology Areas

**Primary:**

- TX11 Software, Modeling, Simulation, and Information Processing
  - TX11.3 Simulation
    - TX11.3.7 Multiscale, Multiphysics, and Multifidelity Simulation